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In re Application of: Stefan Uhlenbrock

Art Unit: 1762

Application No.: To be assigned

Filed: Herewith

For: CHEMICAL VAPOR DEPOSITION METHODS AND APPARATUS

Examiner: To be assigned

Date: June 15, 2001

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COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination of the above-identified application, please amend the application as follows:

In the specification:

On page 1, line 3, please insert the following paragraph:

--Priority Claim

This application is a divisional application of pending U.S. Patent Application No. 09/468,292, filed December 20, 1999.--

Please replace the paragraph beginning at page 12, line 26, with the following rewritten paragraph:

--A second precursor may be dissolved in a solvent to form a second solution 240. Second solution 240 is stored in vessel 242. A source 244 of a suitable inert gas is pumped into vessel 242

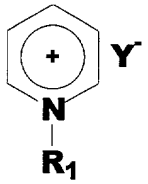
and bubbled through the second solution 240 picking up the second precursor and carrying it into chamber 110 through line 245 and gas distributor 146. Additional inert carrier gas or reaction gas may be supplied from source 248 as needed to provide the desired concentration of precursor composition and regulate the uniformity of the deposition across the surface of substrate 116. As shown, a series of valves 250-253 and 154 are opened and closed as required.--

In the claims:

Please cancel claims 1-28.

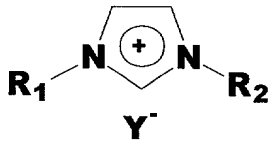
Please add the following new claims:

33. (New) The apparatus of claim 29, wherein the ionic liquid is of the formula:



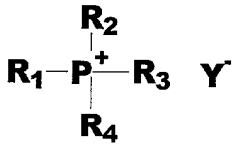
wherein R_1 is alkyl and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

34. (New) The apparatus of claim 29, wherein the ionic liquid is of the formula:



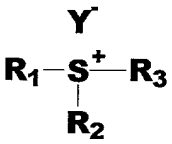
wherein R_1 and R_2 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

35. (New) The apparatus of claim 29, wherein the ionic liquid satisfies the formula:



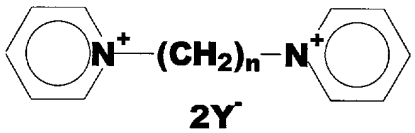
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

36. (New) The apparatus of claim 29, wherein the ionic liquid satisfies the formula:



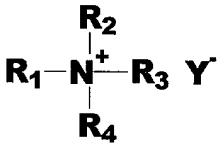
wherein R_1, R_2, and R_3 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

37. (New) The apparatus of claim 29, wherein the ionic liquid satisfies the formula:



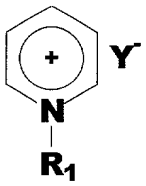
wherein n is from about 1 to about 10 and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

38. (New) The apparatus of claim 29, wherein the ionic liquid satisfies the formula:



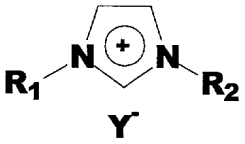
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

39. (New) The apparatus of claim 30, wherein the ionic liquid is of the formula:



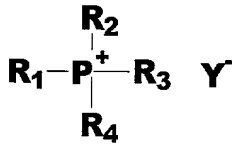
wherein R_1 is alkyl and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

40. (New) The apparatus of claim 30, wherein the ionic liquid is of the formula:



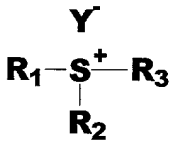
wherein R_1 and R_2 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

41. (New) The apparatus of claim 30, wherein the ionic liquid satisfies the formula:



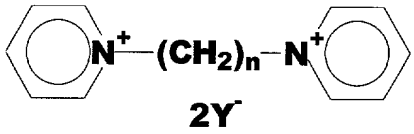
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

42. (New) The apparatus of claim 30, wherein the ionic liquid satisfies the formula:



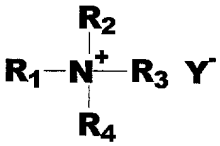
wherein R_1, R_2, and R_3 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

43. (New) The apparatus of claim 30, wherein the ionic liquid satisfies the formula:



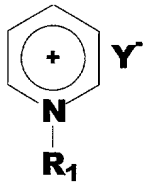
wherein n is from about 1 to about 10 and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

44. (New) The apparatus of claim 30, wherein the ionic liquid satisfies the formula:



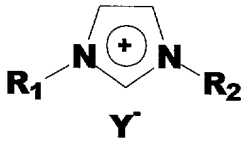
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

45. (New) The apparatus of claim 31, wherein the ionic liquid is of the formula:



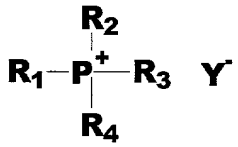
wherein R_1 is alkyl and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

46. (New) The apparatus of claim 31, wherein the ionic liquid is of the formula:



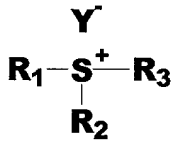
wherein R_1 and R_2 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

47. (New) The apparatus of claim 31, wherein the ionic liquid satisfies the formula:



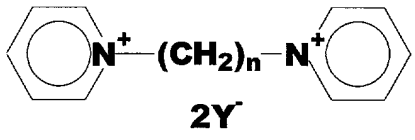
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

48. (New) The apparatus of claim 31, wherein the ionic liquid satisfies the formula:



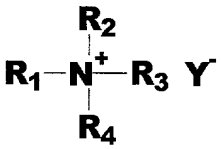
wherein R_1, R_2, and R_3 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

49. (New) The apparatus of claim 31, wherein the ionic liquid satisfies the formula:



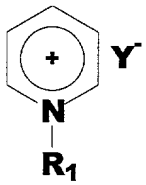
wherein n is from about 1 to about 10 and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

50. (New) The apparatus of claim 31, wherein the ionic liquid satisfies the formula:



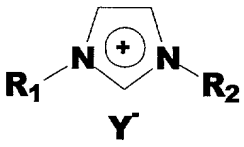
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

51. (New) The apparatus of claim 32, wherein the ionic liquid is of the formula:



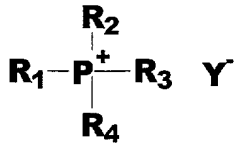
wherein R_1 is alkyl and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

52. (New) The apparatus of claim 32, wherein the ionic liquid is of the formula:



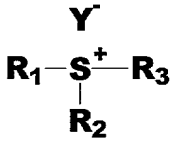
wherein R_1 and R_2 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

53. (New) The apparatus of claim 32, wherein the ionic liquid satisfies the formula:



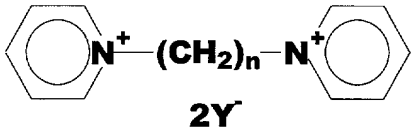
wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

54. (New) The apparatus of claim 32, wherein the ionic liquid satisfies the formula:



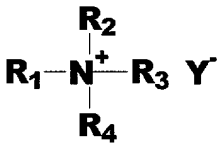
wherein R_1, R_2, and R_3 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

55. (New) The apparatus of claim 32, wherein the ionic liquid satisfies the formula:



wherein n is from about 1 to about 10 and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

56. The method of claim 32, wherein the ionic liquid satisfies the formula:



wherein R_1, R_2, R_3, R_4 are alkyls and Y^- is selected from a group consisting essentially of halides, sulfates, nitrates, acetates, nitrites, tetrafluoroborates, tetrachloroborates, hexafluorophosphates, $[SbF_6]^-$, chloroaluminates, bromoaluminates, chlorocuprates, heteropolyanions, trifluoromethanesulfonates, and mixtures thereof.

REMARKS

Claims 29-32 are pending in the application. New claims 33-56 are added. No new matter is added.

Examination of the subject application is respectfully requested.

CONCLUSION

If any minor issues remain to be addressed prior to examination, the Examiner is respectfully requested to call the undersigned patent attorney at the Portland telephone number listed below.

Respectfully submitted,

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LEIGH & WHINSTON, LLP

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Attorney Reference Number 6047-59237
PATENT

Marked-up Pages of Amended Specification
Pursuant to 37 C.F.R. §§ 1.121(b)-(c)

CHEMICAL VAPOR DEPOSITION METHODS AND APPARATUS

Priority Claim

This application is a divisional application of pending U.S. Patent Application No. 09/468,292, filed December 20, 1999.

Technical Field

The present invention concerns methods for vapor deposition, and particularly concerns methods for providing volatile precursor molecules to form a thin film on a substrate via vapor deposition.

Background of the Invention

Chemical vapor deposition (CVD) is one process for forming thin films on semiconductor wafers, such as films of elemental metals or compounds. CVD involves the formation of a non-volatile solid film on a substrate by the reaction of vapor phase reactants (precursors) that contain desired components of the film. Standard CVD processes use a precursor source in a vaporization chamber of a CVD apparatus. The vaporization chamber is connected to a process (or reactor) chamber wherein a deposition substrate, such as a semiconductor wafer, is located.

CVD (and other thin film vapor deposition) techniques require delivery of a controlled mass of the precursor in the vapor phase. Precise control over the mass of the precursor delivered to the process chamber is needed to form a uniform layer of the desired thin film. In addition, the manner of delivery of the precursor must avoid decomposition of the reactive volatile precursor molecules and must not include unwanted volatized elements or compounds.

Conventional methods of providing a source of vapor-phase precursor molecules include (1) direct vaporization of the precursor from neat solids or liquids, (2) direct vaporization of a solvent containing the precursor, and (3) distilling precursor molecules from a solvent by bubbling a carrier gas through a volume of the solvent containing the precursor.

Closing valve 53 discontinues delivery of the carrier gas containing the precursor to the process chamber 10.

Alternatively, if more than one precursor is to be dissolved in a solvent and transported to a process chamber, the vapor deposition system shown in Fig. 2 may be used. As shown in Fig. 2, the CVD system may include an enclosed chemical vapor deposition chamber 110. The CVD process may be carried out at pressures of from atmospheric pressure down to about 10^{-3} Torr, and preferably from about 10 Torr to about 0.1 Torr. A vacuum may be created in chamber 110 using turbo pump 112 and backing pump 114, or simply a backing pump.

One or more substrates 116 are positioned in process chamber 110. A constant nominal temperature is established for the substrate, preferably at a temperature of about 50° C to about 500° C for certain precursors. Substrate 116 may be heated, for example, by an electrical resistance heater 118 on which substrate 116 is mounted. Other known methods of heating the substrate may also be utilized.

In this process, a first precursor is dissolved in a solvent of the present invention to form a first solution 140 and is stored in vessel 142. A source of a suitable inert gas 144 is pumped into vessel 142 and bubbled through the first solution 140 picking up the first precursor and transporting it into chamber 110 through line 145 and gas distributor 146. Additional inert carrier gas or reaction gas may be supplied from source 148 as needed to provide the desired concentration of precursor and regulate the uniformity of the deposition across the surface of substrate 116. As shown, a series of valves 150-154 may be opened and closed as required.

[A second precursor may be dissolved in a solvent to form a second solution 240. Second solution 240 is stored in vessel 242. A source 244 of a suitable inert gas is pumped into vessel 242 and bubbled through the second solution 240 picking up the second precursor and carrying it into chamber 210 through line 245 and gas distributor 246. Additional inert carrier gas or reaction gas may be supplied from source 248 as needed to provide the desired

concentration of precursor composition and regulate the uniformity of the deposition across the surface of substrate 116. As shown, a series of valves 250-254 are opened and closed as required.]

A second precursor may be dissolved in a solvent to form a second solution 240. Second solution 240 is stored in vessel 242. A source 244 of a suitable inert gas is pumped into vessel 242 and bubbled through the second solution 240 picking up the second precursor and carrying it into chamber 110 through line 245 and gas distributor 146. Additional inert carrier gas or reaction gas may be supplied from source 248 as needed to provide the desired concentration of precursor composition and regulate the uniformity of the deposition across the surface of substrate 116. As shown, a series of valves 250-253 and 154 are opened and closed as required.

Generally, the first and second vaporized precursor molecules are pumped into the process chamber 110 at a flow rate of about 1 sccm to about 1000 sccm. The respective flow rates of the first and second precursors may be varied to provide the desired ratio of first precursor to second precursor in the co-deposited thin film. The substrate 116 is typically exposed to the precursor compositions at a pressure of about 0.001 Torr to about 100 Torr for a time of about 0.01 minutes to about 100 minutes. In process chamber 110, the first and second precursors will form an absorbed layer on the surface of the substrate 116. As the co-deposition rate is temperature dependent, increasing the temperature of the substrate will increase the rate of co-deposition. Typical co-deposition rates are about 10 Å/min. to about 1000 Å/min. Closing valves 153 and 253 terminates the carrier gases transporting the first and second precursors, respectively.

Various combinations of carrier gases and/or vaporized precursors may be used to practice the vapor deposition methods of the present invention. The carrier gas and precursors may be introduced into a process chamber in a variety of manners, as known to those persons skilled in the art.

The vapor deposition methods and apparatus of the present invention include CVD solvents that comprise ionic liquids. As used herein, an ionic liquid